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ABSTRACT

This agriculture extension service publication from Pennsylvania State University is a hardbook for the water body manager. The bulk of the contents deals with aquatic plant control. The different types of aquatic plants, their reproduction and growth, and their role in the ecology of the water body are introduced in this main section. Also, the various management and control practices along with some safety precautions for using herbicides are discussed. In the second section the profiles of fish management and control, including legal restrictions, is examined. (RE)

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CONTROL OF FISH AND AQUATIC PLANTS

SE 024 429

College of Agriculture, The Pennsylvania State University, University Park, Pennsylvania

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CONTROL OF FISH AND AQUATIC PLANTS

AQUATIC PLANTS

THE PROBLEM

Water areas, like land areas, support plant life. The kinds and amounts of plants vary within the different aquatic environments of streams, lakes, ponds, marshes, and other wetlands. Aquatic plants may be the dominant feature of some water areas. In other cases, they may occupy only the water margin, or grow profusely out of sight beneath the water surface; or they may grow as minute particles suspended in the water. Aquatic plants belong to two groups--flowering plants and algae.

The uses and management objectives for a body of water determine, to a large extent, the need for management or control of aquatic plants. In Pennsylvania, a given body of water may be used for fishing, boating, swimming, water skiing, and duck hunting. Plant control may be required to meet the objectives of domestic, industrial, recreational, or agricultural consumption of water.

Floating and submerged plants can interfere with swimming or boating. In fact, dense plant growth can make swimming hazardous. Swimmers are not attracted to murky water, such as is caused by the proliferation of algae. Rooted emergent plants along the shoreline may make it difficult to launch boats and may limit the usefulness of beach areas. Dense vegetation also interferes with fish propagation, hatchery operations, and fishery management. Aquatic plants may give water an off-flavor or fishy odor and make it unfit for drinking without treatment. Free-floating aquatic vegetation often clogs irrigation pipes and nozzles. Some aquatic plants may restrict industrial withdrawls of water.

On the other hand, aquatic plants may be desirable for special purposes. Certain plants and their seeds are useful as cover and food to attract waterfowl for fall hunting. If fishing is a major interest, a limited number of aquatic plants--both floating and submerged--may be desirable. They provide fish with cover, food, and a spawning site. But when they are overabundant, tney interfere with fishing and fish life.

It becomes apparent that the desirability of aquatic plants depends on the point of view of the water user. Reservoir managers and swimmers want clean, clear water that is free of weeds, algae, and other organisms. Waterfowl hunters want an abundance of aquatic plants that attract ducks and geese. Arglers like lily pads, weed beds, and plankton that nurture fish, but not if they become widespread and spoil the fishing. Conservationists strive for suitable plant cover on watersheds and banks of streams, lakes, and ponds to control erosion and to protect water quality. It is clear that the owner or manager of a body of water should be knowledgeable about aquatic plants so that he can choose procedures to meet his management objectives. The application of science to management of water areas and aquatic environments offers the best solution to meeting the diverse interests of all water users.

GROWTH OF FLOWERING AQUATIC PLANTS

The most conspicuous aquatic plants belong to the flowering group. They can be divided into three categories based on the depth of water in which they grow: submergents, floaters (attached or unattached), and emergents.

SUBMERGENTS are found in deep water. They are usually attached to the bottom. Generally they are found entirely under water except for some species which, at flowering time, may protrude a short distance above the surfaces where the action of wind and insects aid in the pollination of flowers. After pollination, flowers and stalks withdraw to below the surface where the fruits mature. Pondweeds, waterweeds, coontail, and water milfoils are among the common submergents found in Pennsylvania waters. Many have roots that are simple and delicate, used only for anchoring plants. The nutrients required for growth are obtained from the surrounding water.

FLOATERS are found in shallow water. Attached floaters, such as water lilies, watershield, and spatterdock usually are rooted in the mucky bottom and absorb their nutrients from the bottom mud. The leaves and flowers either float or are raised slightly above the surface, and the flowers are pollinated by insects. Thick masses of floating leaves reduce light penetration to the bottom, thus limiting the growth of submerged plants below. Unattached floaters, such as the duckweeds, obtain their nourishment from the water. Wolffia, the smallest of the aquatic flowering plants, may grow in clusters and have a single leaf about the size of a pinhead.

EMERGENTS grow along the shoreline in shallow water and are sometimes called marsh plants. Their roots, imbedded in the bottom of the pond, obtain mineral nutrients from the soil. Their stems, leaves, and flowers protrude well above the water line. Emergents include the cattails, arrowheads, rushes, reeds, and sedges. These may grow in moist bog locations or in water up to several feet deep. Spear-like, grass-like, or arrow-shaped leaves are found on many of the aquatic plants in this group. The variation in leaf form, which is related to water depth, sometimes makes identification of certain emergents difficult. For example, the leaves on the same species of arrowhead may vary from straight, spear-like blades to broad, arrow-shaped blades.

Reproduction

Some plants reproduce from seeds that fall into the water and are carried by currents or birds to new aquatic locations. Other seeds may be dispersed by the wind. Some seeds germinate immediately, while others remain in the bottom mud for years before germinating.

In addition to seed production, many aquatic plants also reproduce vegetatively by runners and fragmentation. Species that reproduce by fragmentation present a peculiar problem in control. Mechanical methods of removal, such as cutting and raking, should not be used. If an underwater mowing machine is employed, fragments of the mowed plant float with the current and may grow new roots, anchor, and thrive in another area. The problem is intensified instead of being eliminated.

Winter buds, or turions (coontail and pondweed) produced in the late summer and fall are a method of reproduction for some species of submerged plants. The winter buds preserve the plant through the rigorous cold season.

Effects of Environmental Factors

Environmental factors which inhibit growth are deep water, steep shoreline slopes, unstable bottoms, cold water, colored or turbid water, and water of low fertility. In contrast, lakes or ponds that are subject to dense aquatic plant growth usually have two or more of the following characteristics: shallow depth, gently sloping shoreline, stable bottoms, warm water, clear water, and water of high fertility.

Soft water has a low mineral content which results in low fertility. Ponds or lakes of this nature often have sparse vegetation composed on pondweeds, bladderworts, water lilies, and some species of milfoils. Hard water has a high mineral content and a correspondingly high fertility. Ponds of this type often support a dense growth of many different species.

Fertility of soft water impoundments may be increased through drainage from fertilized fields, feedlots, or barnyards. Nutrients also may be brought in by effluent from septic tanks and other waste disposal systems.

The bottom soil in lakes and ponds influences the number and species of plants that will grow. Most aquatic plants grow best on a mixture of sand and organic soils. Soft, mucky soils may be unfavorable.

GROWTH OF ALGAE

Algae are the most common and most uniformly distributed of all aquatic plants. Pennsylvania waters contain many species, including representatives of the green, blue-green, and yellow-green families, as well as the filamentous and stonewort types.

FILAMENTOUS ALGAE--Many algae, when they occur in masses, can be seen without a microscope. Some appear as thick, filamentous mats, often called pond scum. Others may form a green, fur-like coating on stones and other bottom objects.

PLANKTON ALGAE--All suspended forms of algae make up part of the great numbers of small plants and animals known as plankton. Plankton algae are the most important plants in all natural bodies of water. These microscopic plants utilize carbon dioxide, water, and sunlight to manufacture carbohydrates and other energy chemicals. Thus, they serve as the beginning of the food chain which supports most higher forms of aquatic life. In large numbers, plankton algae may color the water brown, yellow, pea-soup green, or even red during the warm seasons of the year. When this occurs, the lake or pond is said to be "working." These blooms may indirectly provide food for fish, but they may also make water undesirable for swimming or fishing, or for use as a domestic water supply. Each ounce of water in this condition contains millions of microscopic algae cells.

STONEWORT ALGAE--Another type of algae, the stonewort or muskgrass, occurs in quiet waters in areas with limestone soil. Muskgrass has a strong, musky odor, and stonewort is sometimes encrusted with calcium deposits which give a rough, gritty texture. These plants consist of an erect, central main stem from which sprout clusters of branches at various intervals. They may grow as tall as 2 or 3 feet, and can completely cover a pond or lake bottom. Because of their size and growth, these species of algae may be mistaken for flowering plants.

Reproduction

All algae reproduce by spores, cell division, or fragmentation.

CONTRIBUTION OF PLANTS TO AQUATIC ENVIRONMENTS

Energy

Aquatic plants, like all other green plants, use energy from the sun to manufacture carbohydrates. Part of the energy obtained is essential for the growth of the plant itself. The excess energy is stored in the form of carbohydrates, oil, and other products. It is this stored energy that supports most other organisms in aquatic environments. Submerged aquatic plants contribute to the water environment by taking in carbon dioxide and releasing oxygen during photosynthesis.

Food Chain

Algae and flowering aquatic plants form the base of the food pyramid, or the first link in the food chain. These plants are called producers, and must be present in great abundance to support the aquatic animal population, termed the consumers. Organisms that feed directly on these plants are called primary consumers. Part of the energy transferred to the consumer through food is used in its own growth, and the excess is stored. The primary consumer is eaten in turn by the secondary consumer, and so forth as the cycle of energy utilization and storage is repeated up the food pyramid. As the food pyramid becomes taller, or the food chain longer, fewer individual organisms can be supported at higher trophic levels.

The stems and leaves of the submerged parts of flowering plants serve as host for a whole community of microscopic organisms, all of which contribute to the food chain of the pond or lake. Bacteria, fungi, algae, diatoms, protozoans, insect larvae, thread worms, bristle worms, rotifers, and small crustaceans are the principal members of the community of organisms that live on and around the larger plants. The population of this community is spread over all leaf and stem surfaces. Increasing in numbers until the end of the summer, this microscopic community provides support for the larger organisms including fish.

Animal Habitat

The underwater plants contribute in another way to the ecological structure of the total pond or lake community. Many of the free-living and swimming creatures, such as fish and amphibians, use plant beds as places to deposit eggs. The young of many fish use these beds for shelter from predators, or they seek the plants as a feeding area since a rich supply of food organisms is usually available there.

The fisherman and the game fish he seeks are at the top of the food pyramid, and thus the presence of green plants, especially algal plankton, is important to the success of his sport.

Pondweeds, arrowheads, bulrushes, and reeds are important foods for wildlife. The snapping turtle's diet consists of nine-tenths vegetable matter; plants make up two-thirds of the food for the smaller painted turtle. Muskrats eat the rootstocks, tubers, and stems of emergent plants, including cattails, arrowheads, bulrushes, and water lilies. They also use aquatic plants for building their houses and lining their dens.

Filling

In the course of thousands of years, a pond or lake will fill and become dry land. The deeper the lake, the longer it will take to fill. This filling process is aided by the growth of aquatic plants in several ways. The continued cycle of plant growth and decomposition creates a slow building up of organic matter in the basin. Plants also retard the flow of water and thereby cause suspended material to settle to the bottom. As the filling progresses, plants of the shallower zones become established in the former deeper zones. Most bogs and swamps are lakes that are being filled by these processes.

WATER POLLUTION

Pollution associated with aquatic plant growth may be of two types: pollutants which inhibit growth and those which stimulate growth. Although both forms can be serious, this discussion is developed primarily around the growth-stimulating pollutants.

The chemicals that stimulate growth are mainly nitrogen and phosphorus compounds that discharge from sewage plant effluents, home waste disposal systems, food-producing plants, and well-fertilized agricultural watersheds. These materials stimulate profuse growth of both algae and flowering aquatic plants.

Depending on conditions, a polluted pond or lake may be either excessively turbid and scum coated or clear and choked with weeds. Either condition indicates water of relatively high fertility and optimum conditions for algae or for larger plants. These conditions are often created by wastes from housing subdivisions, cabins, and cottages. Sewage effluent from these installations reaches the streams and lakes of the local watershed. Sewage treatment or disposal systems that meet governmental requirements may not circumvent the problem of increased fertility; nitrates and phosphates remaining in treated sewage stimulate plant growth in receiving waters.

Fish Kills

Dense aquatic plant growth may cause oxygen depletion and subsequent fish kills. Warm, calm, and cloudy weather in summer and thick, opaque or snow-covered ice in winter contribute to this hazard. Under these conditions, plants do not photosynthesize and produce oxygen. Instead, they only respire and consume oxygen and some may die and decompose. Organic decomposition occuring throughout the year, makes a continuous demand upon available oxygen. If oxygen is not available through wave action, inflowing water, or photosynthesis, oxygen levels may be reduced to levels inadequate for fish and many of their food organisms.

MANAGEMENT AND CONTROL OF AQUATIC PLANTS

An aquatic weed can be simply defined as an aquatic plant that grows when and where it is not wanted. For example, spatterdock offers a desirable habitat for various species of fish and is pleasing to look at, but a patch of spatterdock that clogs the area around a boat dock is a nuisance to those using the dock. Obviously, waters with a variety of users are likely to contain aquatic plants that are considered desirable to some groups and objectionable to others. Compromise, therefore, may be necessary in managing the vegetation in a pond or lake.

Aquatic weed control requires skill. All possible consequences of a program should be carefully weighed. The first step in control is to identify the problem plants. Along with identification, something should be known about the life history and growth pattern of the problem plants. Once the plant is identified and the problem is understood, control can be planned.

The basic methods for controlling aquatic plants are mechanical, biological, and chemical. They can be, and often are, used in combination. Another control technique--which may incorporate mechanical, biological, or chemical methods--is to change the environment.

Mechanical Control

Physical removal is most effective for small quantities of plants near shorelines. The technique consists of cutting, mowing, raking, digging, or pulling. In small ponds, lakes, or streams, plants like sedges, reeds, cattails, and rushes can be mowed with a sickle or scythe or dug out with a hoe. Small patches of water lilies or spatterdock may be cut or pulled and destroyed before extensive growth occurs. However, pulling or cutting must be repeated several times to eliminate all new growth as soon as it appears. Single treatments are usually not effective because of the extensive tubers and root systems of some aquatic plants.

Attempts to remove submerged plants--by cutting or dragging a chain or cable over the bottom are not effective. Actually, this practice may cause spreading of the plants because each stem fragment left in the water is a potential new plant. For larger areas, special cutting machines have been developed that can be adjusted to cut at various depths. Several cuttings are required each year.

In small ponds, thin black plastic has been used to eliminate plant growth. When plastic is placed on the bottom in early spring it prevents the resumption of growth of rooted aquatics. This technique can be especially effective in private waters where special local control around boat docks or at the edge of weed beds is desired.

Environmental Control

Deepening very shallow ponds or lakes to 10 feet or more offers the most permanent method of weed control. With man-made lakes and ponds, the cost of doing this may be high at the time the pond is constructed, but it is more expensive to dredge to this depth after the pond is built. At depths of 10 feet or more, it is unusual for submerged vegetation to reach close to the surface. Sunlight penetration at this depth usually is not sufficient to stimulate vigorous growth of most aquatic plants.

LOWERING AND FREEZING--Good seasonal control of some aquatic plants, especially milfoil and some of the pondweeds, has been achieved by partially draining the pond or lake in late fall or early winter to expose the shallow portions of the bottom to freezing temperatures. Effective control is usually assured if the bottom mud freezes to a 4-inch depth for a period of 3 weeks or longer. When a 50-acre lake is reduced to 10 or 15 acres, oxygen depletion is more likely to occur because fish and organic debris are concentrated in a smaller volume of water.

ALTERING SLOPES--With reeds, sedges, rushes, and floating species such as water lilies, steep sides that drop off rapidly into deep water (5 feet or more) will usually reduce growth or limit it to the very edge of the pond, where the weeds may be cut easily with a scythe or by other mechanical means. However, steep sides may create other problems. If small children frequent a pond, steep sides may be a safety hazard.

Spawning of some species of fish requires shallow water and aquatic vegetation for successful reproduction. While protection from predation is provided to small game fish if aquatic plants are present, excessive plant growth can be harmful in the overprotection of undesirable species.

FERTILIZATION of ponds or lakes in the early spring may stimulate the growth of plankton and change the environment. Fertilized waters become greenish or brownish in the warm season, reflecting the presence of millions of minute plants and animals. This "bloom" restricts the penetration of sunlight to the bottom, inhibiting photosynthesis and depressing the growth of submerged plants.

The results of fertilization in Pennsylvania are unpredictable and should be considered only when a body of water is small (a few acres or less), the rate of water exchange is very slow, and warm-water fish production is the prime objective. Under these conditions, the well-planned use of fertilizer may be helpful in controlling rooted aquatic plants. However, in most cases, pond fertilization stimulates existing rooted aquatic plants and increases the weed problem instead of reducing it.

Biological Control

Animals that are dependent on aquatic plants for food are of limited value for the control of these plants. Muskrats may cut considerable quantities of plants, but in doing so, leave fragments that may act as sources for plant propagation. Waterfowl may utilize certain floating and submerged plants; however, the fertility resulting from their excrement may create excessive algal blooms that may be even less desirable than the original problem. Some exotic species of fish such as the white amur are being promoted to control aquatic vegetation. Since the impact of these fish on aquatic ecosystems in Pennsylvania is not fully known, the possession or release of these fish into waters of the Commonwealth is prohibited by The Pennsylvania Fish Commission.

Chemical Control

Herbicides offer a solution to many otherwise difficult aquatic weed problems. But chemical control has its own special set of limitations. Treatment must not be performed in a haphazard or careless manner.

CAUTIONS--Chemical control is more specialized and precise than other methods, but it too has pitfalls. Most unsuccessful weed control programs are not the fault of the herbicide. Failures are usually the result of errors in calculation or of the improper use of chemicals. Inadvertent damage such as fish kills can usually be traced to errors in judgment, arithmetic, or application of a chemical.

LEGAL CONSIDERATIONS--The introduction of any chemical into waters of the Commonwealth is subject to regulation under the Clean Streams Law and under Pennsylvania Fish Laws. Special rules and regulations provide for application for and issuance of permits which are required for the use of algicides, herbicides, and fish-control chemicals.

Article 800. Section 3

Use of Algicides, Herbicides, and Fish Control Chemicals

"Except where the use of an algicide, herbicide or fish control chemical would be in violation of a specific Departmental order or permit, such use is authorized in the following instances only:

(a) copper sulfate required to control algae in a source of public water supply where such use is pursuant to and in accordance with approval given by the Commonwealth;

(b) chemicals required to control aquatic plants in surface waters and chemicals required for the management of fish populations where such use is pursuant to and in accordance with joint approval given by the Department of Environmental Resources and the Fish Commission."

When chemical treatment is planned, the first step is to submit an application form (a sample is on page 11) properly completed, signed and witnessed. It then goes to the Pennsylvania Fish Commission, Fisheries Management Section, R.D. #1, Box 70, Bellefonte, Pennsylvania 16823. The forms may be obtained from the following agencies:

- Regional Offices of the Pennsylvania Fish Commission or Pennsylvania Department of Environmental Resources
- Fish Commission county waterways patrolmen
- Pennsylvania Department of Agriculture district offices
- County Conservation District offices
- Pennsylvania State Soil and Water Conservation district offices.
- District foresters' offices
- U.S.D.A. Soil Conservation Service county offices

A separate application must be filed for each body of water to be treated. Only one application is required for waters receiving several treatments in any one year; however, the frequency of treatment and the total dosage must be clearly stated. Submission of a new application is required for each successive year for those water bodies requiring continuous year-to-year treatment.

The applicant must complete all items on the application form. The following is an explanation of items that may not be clearly understood:

3. Enter the official name of the water body to be treated as it is given on a U.S. Government Survey topographic map. If the water body has no official name, give a local name.

11. It is extremely important that an accurate average depth figure be given.

13. State the commercial name(s) of the control chemical(s) to be used.

14. (a and b) Give the dosage per treatment in pounds or gallons of each chemical to be used. The labels of most chemical products utilized as algicides, herbicides, or fish control chemicals give recommended dosages per <u>surface acre</u> or <u>acre foot</u>. State as listed in manual or on manufacturer's label.

(c) Give the amount of chemical to be used in one <u>treatment</u>. If more than one treatment, also complete part (e).

(d) State the number of treatments to be made this year.

(e) State the total amount of each chemical to be used in <u>all</u> treatments.

15. Indicate as accurately as possible the proposed date(s) of treatment, and do not fail to notify the local Fish Commission waterways patrolman prior to treatment.

17. Give special attention to this item, as <u>failure to do so</u> may result in your liability for any damages caused. ("Riparian" users are landowners whose property borders on the downstream watercourse.)

19 and 20. Applicant and witness must sign completed application to make it valid.

COMMONWEALTH OF PENNSYLVANIA
FISH COMMISSION - DEPARTMENT OF ENVIRONMENTAL RESOURCES

APPLICATION AND PERMIT FOR USE OF AN ALGICIDE, HERBICIDE OR FISH CONTROL CHEMICAL IN WATERS OF THE COMMONWEALTH

Submit all applications (only one copy necessary) to the Pennsylvania Fish Commission, Fisheries Management Section, R.D. #1, Box 70, Bellefonte, Pennsylvania 16823

1. Name of applicant (owner) _____ Tel. No. _____

   Address of applicant _____

2. Person or organization conducting treatment (if other than applicant) _____

   _____

3. Name of water body to be treated _____

4. Location of water body: County _____ Township or other municipality

   _____ Nearest built-up area _____

5. Type of water body: Pond _____ Lake _____ Impoundment _____ Canal _____

6. Uses of water body to be treated:

   Water Supply: Municipal _____ Industrial _____ Livestock _____ Irrigation _____

   Fire Protection _____ Other _____

   Water Contact Sports: Swimming _____ Skiing _____

   Fishing: Warm water species _____ Cold water species(trout) _____

7. Is water body open for public fishing? Yes _____ No _____

8. Has water body ever been stocked with fish by a State Agency? _____ Federal Agency _____

9. Does water body have a discharge or overflow of water? Yes _____ No _____

   If yes, indicate time of year discharge or overflow will occur _____

10. Name of receiving stream _____

11. Total area of water body: Number of surface acres _____

    Treatment area: Number of surface acres _____ Average depth _____

12. Indicate species of algae, plant(s), or fish to be controlled _____

    _____

13. Commercial name(s) of chemical(s) _____

SAMPLE

14. Dosage of each chemical per treatment (specify in either pounds or gallons)

(a) _____ per surface acre _____ per surface acre

(b) _____ per acre foot _____ per acre foot

_____ per acre foot _____ per acre foot

(c) Amount of each chemical to be applied in each treatment _____

_____(pounds or gallons)

(d) Number of treatments to be made this year _____

(e) Total amount of each chemical to be applied in all treatments _____

_____(pounds or gallons)

15. Proposed date or dates of treatment _____
(Local Fish Commission Waterways Pratrolman MUST be contacted prior to treatment.)

16. Additional remarks or information _____

_____

17. Have all other riparian users, both in the vicinity of the treatment area and downstream who may be required to restrict their usages as a result of this treatment:

(a) Approved your plans? Yes ___ No ___ (b) Agreed to restrictions? Yes___ No ___

18. The applicant: (a) Certifies the truth of the above statements; (b) Agrees to employ the listed chemicals in conformance with the manufacturer's specifications and with all the conditions of the permit; (c) Is responsible for all damages incurred by the chemicals used.

SAMPLE

19. Applicant's signature _____ Date _____

20. Witness' signature _____ Date _____

FOR REVIEWER'S USE ONLY APPLICATION AND PERMIT NO. _____

Reviewer's Action:

Agency	Reviewer	Title	Date	Approve	Disapprove
Fish Commission					

Remarks _____

_____

Environmental Resources

Remarks _____

_____

Application of Herbicides

Apply chemicals in accordance with the manufacturer's label instructions. These instructions generally include recommended equipment and dosage, and suggested time of application; they are specific for the plant species to be controlled. Proper equipment will save time and labor and will permit uniform application. The chemical should be applied when the plant is most susceptible, and the dosage used should never exceed the amounts listed on the label.

Only the active ingredient of most commercial herbicides is the effective controlling agent. In some instances the recommended dosage is based on the active ingredient. Therefore, one must know the percentage of active ingredient in the material before he can plan the application rate, and before he can compare the cost of one herbicide with another. Percentage of active ingredient data is printed on the manufacturer's label.

DOSAGE CALCULATIONS--The need for strict adherence to proper procedure and accurate calculations cannot be overemphasized. Accurate dosage is essential, especially in view of the relatively small concentration of chemicals used in aquatic situations. The concentrations used are so low that they are most conveniently expressed as parts per million (ppm). For example, if a 2 ppm concentration of the active ingredient in a herbicide will kill an aquatic weed, it means that the concentration for the proposed treatment should be in a ratio of 2 parts of the active ingredient to 1 million parts of water.

In order to calculate the amount of chemical to be used, it is necessary first to know how much water is in your pond. If it was constructed under the direction of the Soil Conservation Service, you probably can obtain a very precise value for the volume of the pond. If these data are not readily available, it will be necessary to calculate the total volume from your measurements of surface area and average depth. Total volume in acre-feet can by obtained by multiplying the surface area (in acres) by the average depth (in feet). For example, a 2-acre pond with an average depth of 4 feet contains 8 acre-feet of water. An acre-foot of water weighs 2.7 million ponds. Therefore, a concentration of 1 ppm can be obtained by applying 2.7 pounds of the active ingredient to 1 acre-foot of water. The example pond has 8 acre-feet of water, so 21.6 (2.7 x 8) pounds of active ingredient would be needed for 1 ppm concentration. To get a concentration of 1/2 ppm in the 8 acre-foot pond, multiply 2.7 x .5 x 8. The product, 10.8, is the number of pounds required. The volume of small ponds may best be handled as cubic feet, computed by multiplying surface area in square feet by the average depth in feet. Thus, if a pond has a surface of 5,000 square feet and an average depth of 4 feet, it would contain 20,000 cubic feet of water. Since one cubic foot of water weighs 62.5 pounds, there would be 1,250,000 pounds of water in the pond. To achieve a 1 ppm concentration, 1.25 pounds of active ingredient would be needed.

It is important that the chemical user realize that the amount of chemical a given pond will require depends on the amount of active ingredient in the chemical. A small amount of chemical with a high percentage of active ingredient may work as well as a large amount of chemical with a low percentage of the same active ingredient. It may also be more economical. Two conversion tables are included on pages 14 and 15 to help compare products of different concentrations.

Gallons of liquid chemical needed (based on the pounds of active ingredient per gallon) to treat one acre-foot of water with 1 to 10 parts per million concentration:

Pounds of Active Ingredient Per Gallon	Parts Per Million									
	1	2	3	4	5	6	7	8	9	10
1	2.719	5.438	8.157	10.876	13.595	16.314	19.033	21.752	24.471	27.190
2	1.359	2.718	4.077	5.436	6.795	8.154	9.513	10.872	12.231	13.590
3	0.906	1.812	2.718	3.624	4.530	5.436	6.342	7.248	8.154	9.060
4	0.680	1.360	2.040	2.720	3.400	4.080	4.760	5.440	6.120	6.800
5	0.544	1.088	1.632	2.176	2.720	2.264	3.808	4.352	4.896	5.440
6	0.453	0.906	1.359	1.812	2.265	2.718	3.171	3.624	4.077	4.530
7	0.388	0.776	1.164	1.552	1.940	2.328	2.716	3.104	3.492	3.880
8	0.340	0.680	1.029	1.360	1.700	2.040	2.380	2.720	3.060	3.400
9	0.302	0.604	0.906	1.208	1.510	1.812	2.114	2.416	2.718	3.020
10	0.272	0.544	0.816	1.088	1.360	1.632	1.904	2.176	2.448	2.720

Pounds of chemical needed (based on the percent of active ingredient) to treat one acre-foot of water with 1 to 10 parts per million concentration

Percent Active Ingredient	PARTS PER MILLION									
	1	2	3	4	5	6	7	8	9	10
1	270.0	540.0	810.0	1080.0	1350.0	1620.0	1890.0	2160.0	2430.0	2700.0
2	135.0	270.0	405.0	540.0	675.0	810.0	945.0	1080.0	1215.0	1350.0
3	90.0	180.0	270.0	360.0	450.0	540.0	630.0	720.0	810.0	900.0
4	67.5	135.0	202.5	270.0	337.5	405.0	472.5	540.0	607.5	675.0
5	54.0	108.0	162.0	216.0	270.0	324.0	378.0	432.0	486.0	540.0
6	45.0	90.0	135.0	180.0	225.0	270.0	315.0	360.0	405.0	450.0
7	38.6	77.2	115.8	154.4	193.0	231.6	270.0	308.8	347.4	386.0
8	33.8	67.6	101.4	135.2	169.0	202.8	236.6	270.4	304.2	338.2
9	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0	300.0
10	27.0	54.0	81.0	108.0	135.0	162.0	189.0	216.0	243.0	270.0
11	24.5	49.0	73.5	98.0	122.5	147.0	171.5	196.0	220.5	245.0
12	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0
13	20.8	41.6	62.4	83.2	104.0	124.8	145.6	166.4	187.2	208.0
14	19.3	38.6	57.9	77.2	96.5	115.8	135.1	154.4	173.7	193.0
15	18.0	36.0	54.0	72.0	90.0	108.0	126.0	144.0	162.0	180.0
16	16.9	33.8	50.7	67.6	84.5	101.4	118.3	135.2	152.1	169.0
17	15.9	31.8	47.7	63.6	79.5	95.4	111.3	127.2	143.1	159.0
18	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0
19	14.2	28.4	42.6	56.8	71.0	85.2	99.4	113.6	127.8	142.0
20	13.5	27.0	40.5	54.0	67.5	81.0	94.5	108.0	121.5	135.0
21	12.9	25.8	38.7	51.6	64.5	77.4	90.3	103.2	116.1	129.0
22	12.3	24.6	36.9	49.2	61.5	73.8	86.1	98.4	110.7	123.0
23	11.7	23.4	35.1	46.8	58.5	70.2	81.9	93.6	105.3	117.0
24	11.3	22.6	33.9	45.2	56.5	67.8	79.1	90.4	101.7	113.0
25	10.8	21.6	32.4	43.2	54.0	64.8	75.6	86.4	97.2	108.0
50	5.4	10.8	16.2	21.6	27.0	32.4	37.8	43.2	48.6	54.0
100	2.7	5.4	8.1	10.8	13.5	16.2	18.9	21.6	24.3	27.0

HAZARDS OF CHEMICALS--Many herbicides are toxic to fish and other animals, including human beings, but the amounts needed to kill aquatic weeds are generally less than the tolerance level of fish and other animals. Newly hatched fish appear to have less tolerance to herbicides than do older fish. In some areas, minor fish kills may occur when safe dosages are exceeded or when chemicals are distributed unevenly.

Fish mortality may also occur as an indirect result of chemical weed control because of the oxygen consumed by the rapid decay of the destroyed plants. To minimize this danger, treat only 1/3 of the pond at any one time, spacing applications at least one week apart so that rapid plant decay will not reduce the oxygen in the water to a dangerously low level. Chemical control of aquatic weeds must be undertaken with considerable care and adequate planning.

Control of Algae

Most serious problems with algae are usually associated with domestic water supply reservoirs or small farm ponds.

Control is most effective and least costly when undertaken before the algae become dense enough to constitute a problem. Some reservoir managers make a daily microscopic examination of the water to determine when treatment should be scheduled. Through experience with a given body of water, one may be able to anticipate when chemicals should be applied.

The amount of chemical per treatment and the number of required treatments varies with the hardness of the water. In soft water, one treatment may suffice. In hard water, however, three or four treatments may be needed throughout the summer because the regrowth of algae can be quite rapid in such water. If results are not evident within seven days after treatment, another application may be made.

Trout are very sensitive to some chemicals, especially copper sulfate, and cannot tolerate levels required for control of certain species of algae. (Copper sulfate is not recommended where trout are present.) Other fish cannot tolerate levels much in excess of those required for algal control. Fish in soft-water lakes and ponds are particularly vulnerable to copper-containing algicides; repeated applications may reduce fish populations either through direct toxicity or indirectly through elimination of sensitive fish food organisms.

Chemicals may be applied in several ways, all of which can produce good results if there is uniform distribution. Chemicals can be dissolved in water and sprayed on the surface. To eliminate heavy mats of filamentous algae, chemicals can be applied directly to the mats. Applications should be made on warm, sunny days; under these conditions algae are growing vigorously and are most vulnerable.

Control of Submerged Plants

Submerged plants complete their entire life cycle, exclusive of flowering and pollination, under water. Waterweed is typical of submerged plants that grow in dense stands or mats. Other troublesome submerged species that grow densely include pondweed, bushy pondweed, water milfoil, coontail, fanwort, and bladderwort.

Chemicals for controlling submerged weeds can be applied in various ways. Granules may be spread from a boat, from the shore, or by aircraft. Care must be taken to obtain uniform coverage. Granules are especially useful for spot treatments near boat landings or swimming areas. Liquid herbicides may be sprayed or pumped into the water. Again, boats, aircraft, or even hand pumping from the shoreline may be used. As a rule, the more evenly the chemical is distributed, the better the results will be. Spot treatment of problem areas with liquids in very large lakes may be feasible. Usually more material per acre-foot of water is needed when making spot treatments than when making overall treatments, because the nontreated adjacent water will have a diluting effect. Where dense weeds cover an entire pond, only one-third of the pond should be treated at a time to prevent oxygen depletion due to decaying plant growth. Applications should be made at weekly intervals.

Control of Emergent Plants

Emergent plants may grow in moist or swampy shoreline soils and extend into water three feet or more in depth. Many emergents are valuable duck foods, and should not be eliminated if waterfowl are wanted. Principal types include species of rushes, bulrushes, cattails, reeds, sedges, and arrowheads.

Foliar sprays should be applied in early summer as the leaves are approaching full size, but before flowering. If water is used as the diluent or carrier, a small amount of detergent or other wetting agent will improve coverage of the plant surfaces. The plant foliage should be completely wetted. Applications should be made during mid-day periods when the foliage above water is free from dew or rain.

Granular formulations act more slowly than liquids, but they may give more long-lasting results. If vermiculite or a similar carrier is used, the herbicide may be spread with a cyclone seeder or by hand. The granules settle to the bottom and release the chemical that will be absorbed through the plant roots. Applications in late winter may be made on the ice. As the ice melts, the granules settle to the bottom. As with foliar sprays, granular applications are made in late summer or fall, however, the effects may not be noticed until the following spring when the treated plants fail to develop. If granules are spread on choppy water, distribution will be uneven, and results may be unsatisfactory.

In making spray applications for controlling emergent weeds, there are two basic methods of calculating the dosage and application rate: (1) quantity of herbicide per surface area treated, and (2) quantity of herbicide per volume of spray solution.

For treating areas of one acre or more, the first method should be used. The important consideration with this method is the amount of herbicide applied per acre. The amount of carrier will vary with the spray equipment, nozzle sizes, and pressure. For treating areas of less than one acre, it is more practical to use the herbicide-per-volume method and to spray foliage to the run-off point or until thoroughly wetted. With most herbicides, the container label will give directions for applications by both methods.

Control of Floating Plants

In Pennsylvania, the most common floating plants are duckweed, water lily, spatterdock, and watershield. The water lily types are valued by fishermen as long as ample room is left for fishing, but in areas used for boating, swimming, or water skiing, water lilies are serious nuisances and must be kept under control.

Plants and the water surface should be treated by spraying, taking care to obtain even distribution in the area of plant growth. If water is colder than 60° F., or if plants are not growing actively, the area should not be sprayed. For floating plants that are rooted on the bottom, granular formulations may be used.

The applicator should consider only those herbicide formulations specifically registered and labeled for aquatic weed control.

Equipment and Treatment

The 3- to 5-gallon pressure-type sprayers available at most home garden centers and hardware and farm supply stores are adequate for treating small ponds. Ponds of 5 acres or more may be more efficiently treated with heavier, commercial-type spray equipment.

Granules can be spread by hand in small areas such as boat landings and swimming sites. Hand-operated, crank-type fertilizer and seed spreaders will do a satisfactory job in larger areas. Larger versions of these spreaders are used for large-scale commercial granule applications. They operate on the principle of the cinder spreaders used on highways, and are capable of dispersing granules in 30- to 35-foot swaths. These units are often powered by a 12-volt D.C. motor that operates from an auto battery. Helicopters and airplanes have been used effectively to apply chemicals, particularly granules, in large-scale operations.

Precautions

Chemicals, especially 2,4-D and silvex sprays, should be applied on a calm day when dangers from drifting can be avoided. With such precautions, damage to desirable vegetation is minimal, and operators are protected from excessive contact and inhalation of spray.

Chemical spillage, especially around stock pond areas or where pets and children may be exposed, must be cleaned up. Herbicides should never be stored where children can reach them. Labels should be studied and their instructions for safe and proper use observed.

Herbicide application can start at the margins of the lake or pond and progress toward the deep water. Fish and other organisms will tend to move ahead of the herbicide-treated water into the deeper areas where toxic concentrations can be avoided.

Treatment Techniques

Lakes and ponds that have a high rate of inflow should be lowered prior to treatment so as to insure adequate contact time for the herbicide. The spillway should be closed and the treated water retained for at least 3 days before overflow. The amount of drawdown will vary according to the situation. Care must be taken to avoid excessive exposure of bottom areas.

After the application is completed, the spray equipment should be flushed with large quantities of water.

Waters should be treated for aquatic weeds in late spring or early summer when plants are young and actively growing. Treatment at this time of year usually gives optimal control with a minimum of chemical. Applications in late summer or early fall require more chemical and usually give slower, erratic control. Furthermore, access to normally dense aquatic vegetation is best in the spring or early summer before the plants reach the surface.

Points to remember--The applicator should:

1. Be certain of the identity of the vegetation to be treated and the capability of the chemical to control it.
2. Obtain a permit to treat any lake or pond, whether for weed control, cleaning, or other purposes.
3. Never use more chemical than suggested on the label. Fish and other valuable aquatic life may be killed.
4. Use treated water only as suggested on the label.

ENVIRONMENTAL CHANGES CAUSED BY AQUATIC PLANT CONTROL

The sudden elimination of a dense growth of vegetation from an aquatic environment very often causes side effects that can produce significant changes in the biological and physical makeup of a lake, pond, or stream.

Following the death of larger weed plants in a pond or lake, a greenish or yellowish-brown turbid condition may be noticed. This condition is due to the presence of billions of microscopic algal cells which have utilized the nutrients for growth and reproduction. The blue-green algae are often responsible for a green pea-soup appearance, whereas other algae and various one-celled organisms cause the yellowish-brown colors in water. When conditions are optimal for development of algae, a dense bloom can develop quickly. These dense blooms of plankton algae cut down light penetration and thereby inhibit the reestablishment of those species killed in treatment, but the algae may turn out to be more objectionable than the original weed infestation.

Some aquatic vegetation is necessary for the reproduction and survival of certain fish (pickerel, golden shiners, and others). It follows that where desirable fish are dependent on aquatic vegetation, portions of water should be left untreated.

SUMMARY

Aquatic plants provide habitat in lakes and ponds for waterfowl and fish, but may be in conflict with certain types of water use.

Aquatic plants add essential oxygen to the water, but under some conditions, their respiration and decomposition may reduce the oxygen to dangerously low levels for fish survival.

Aquatic plants play an important role in food chains; however, too many plants may contribute to overcrowded and poor quality fish populations.

There is no easy cure-all for controlling undesirable aquatic vegetation. Dredging to deepen shallow edges may help, but may also create hazards and fish management problems.

Aquatic plant control with chemicals can be successful and very satisfactory. Once a weed problem is under control, diligent treatment of regrowth is necessary to maintain control. It is much easier and less expensive to conduct periodic maintenance or to make spot treatments than it is to wait until treatment of the entire area is necessary.

Today's aquatic plant control techniques are far from adequate. New chemicals for control of certain species, even though successful, are not likely to end all problems in themselves. Techniques are needed that will limit water plants without causing harmful side effects to man or other desirable organisms.

COMMON AQUATIC PLANTS AND CONTROL MEASURES

PLANT SPECIES	MECHANICAL METHODS	ENVIRONMENTAL METHODS	CHEMICALS*
Algae			
Green, blue-green filamentous forms, and other types, including stonewort algae	In very small ponds, rake or drag. This is effective only with the mat-forming filamentous types.	Reduce nutrients such as sewage effluent, animal wastes, fertilizer runoff, etc.	Copper sulfate Diquat Elemental copper (as triethanolamine-copper complex) Endothall
Submergents			
Coontail and pondweeds	Mechanical harvesting machines are of some use. Many species reproduce vegetatively from plant fragments, and cutting may only make problems worse. This is true for most submergent plants.	Increase water depth. Make sides steeper.	2,4-D Diquat Endothall Silvex
Fanwort	Same as for coontail and pondweeds	Same as for coontail and pondweeds	Silvex
Bladderwort	Same as for coontail and pondweeds	Same as for coontail and pondweeds	2,4-D Diquat Silvex
Bushy pondweeds--Naiad	Same as for coontail and pondweeds	Same as for coontail and pondweeds	2,4-D Diquat Endothall

*Subject to change. Check current labels for complete list of weeds and rates of application. In some cases, combinations of two or more of the chemicals are available (endothall and silvex, for example).

READ THE ENTIRE LABEL BEFORE USING ANY PESTICIDE

PLANT SPECIES	MECHANICAL METHODS	ENVIRONMENTAL METHODS	CHEMICALS
Milfoil	Same as for coontail and pondweeds	Same as for coontail and pondweeds	2,4-D granules Diquat Endothall Silvex
Waterweed--Elodea	Same as for coontail and pondweeds	Same as for coontail and pondweeds	2,4-D Diquat Endothall Silvex
Floaters--attached			
Water lily and spatterdock	For small ponds or limited areas, repeated cutting and pulling can be successful.	Increased water depth and steeper sides will reduce the problem.	2,4-D Silvex
Water shield	Same as for water lily and spatterdock	Same as for water lily and spatterdock	2,4-D
Floaters--free			
Duckweed	Skimming		Diquat
Emergents			
Cattail	Same as for attached floaters	Same as for attached floaters	2,4-D Diquat Dalapon
Arrowhead	Same as for attached floaters	Same as for attached floaters	2,4-D Silvex
Water smartweed	Same as for attached floaters	Same as for attached floaters	2,4-D

SAFETY PRECAUTIONS

Chemicals should be stored in a dry, dark room and protected from extremes in temperature. Always store herbicides away from other pesticides, fertilizers or seeds to prevent contamination of these products by the herbicides. Dusts and wettable powders are easily stored and should not become a problem as long as they are kept dry. If these are stored under damp or wet conditions, they often cake and become impossible to use. Packages of hygroscopic (water absorbing) chemicals, such as copper sulfate, will cake when left open by absorbing moisture from the air. Many compounds, such as diquat, are photodecomposed and should be stored in the dark. Chemicals with a low flash point (140° F. or less) are dangerous to store and should be treated with caution. Chemicals should not be subjected to below-freezing temperature because this will damage many formulations.

COPPER SULFATE AND ELEMENTAL COPPER (derived from triethanolamine--copper complex or ethylenediamine-copper complex)

Advantages: Low toxicity to human beings and other mammals.

Disadvantages: High toxicity to fish and invertebrates; corrosive to metals, generally needs high light intensities for herbicidal action.

Antidote or Treatment: Copper Sulfate--excess excreted in mammals. Copper Complex--low toxicity, but if toxic poisoning is suspected, call a doctor. If skin contact is made, wash thoroughly. If it gets into eyes, wash them thoroughly and call a doctor.

DALAPON

Advantages: Oral toxicity is low.

Disadvantages: May cause skin irritation after prolonged contact.

Antidote or Treatment: Flush skin with plenty of water. Remove contaminated clothing and clean before reuse. Get medical attention if any irritation develops. If it gets into the eyes, flush with plenty of water and get medical attention promptly.

Antidote or Treatment: No known antidote. Treat symptomatically.

DIQUAT

Advantages: Nonvolatile and nonflammable.

Disadvantages: Highly toxic.

Antidote or Treatment: Wash affected parts thoroughly. If ingested, flush intestinal tract, use saline cathartics, treat symptomatically.

ENDOTHALL

Advantages: Noncorrosive and nonflammable.

Disadvantages: Oral toxicity to mammals is high and ingestion must be dealt with carefully.

Antidote or Treatment: In case of contact, immediately flush skin or eyes or other exposed areas with plenty of water for at least 15 minutes. For eyes, get immediate medical attention. If swallowed (which may be fatal) give cold milk or cold water. Call a physician.

SILVEX

Advantages: Usually less drift than with other phenoxy, auxin-like herbicides.

Disadvantages: Many common species are resistent to Silvex.

Antidote or Treatment: Silvex is only slightly toxic to humans; therefore, no antidote is necessary.

2,4-D

Advantages: Effective control of many broadleafed plants including some aquatic plants.

Disadvantages: Drift is a hazard to near-by susceptible plants.

Antidote or Treatment: Treat symptomatically.

FISH CONTROL

THE PROBLEM

Frequently an undesirable species of fish is introduced into an aquatic ecosystem. If the species becomes established, it may have an adverse effect on the aquatic environment or on other more desirable species of fish. Under such circumstances, the offending species should be eliminated or controlled.

Control is also desirable when one or more species of panfish or forage fish overpopulate an aquatic environment. Where predator populations are not large enough to control such species, or if they are not harvested (fished), they may proliferate enough to outstrip their food supply. Fish seldom starve to death; the lack of food reduces growth, causing small, stunted fish. Therefore, to optimize the fishes' growth rate, the control of panfish and forage species is essential to maintain a balance between fish and available food.

TYPES OF CONTROL

Fish control may be accomplished by manipulating the environment or by using mechanical, biological, or chemical control. Regulations dealing with fish stocking and harvesting may prove effective in controlling fish populations. These methods may be used singly or in combinations.

Control of fish is regulated by state laws. The permit system currently used for various control measures is explained at the end of this section.

MANIPULATING THE ENVIRONMENT

Fish populations can be effectively controlled in impoundments where water level can be controlled. Undesirable species may be eliminated from a pond by draining the pond completely, removing the undesirable species, and then refilling and restocking with preferred species.

Additional control measures may be necessary to remove an undesirable species from isolated pockets of water in large dams or lakes where a complete drawdown is impossible. Dams with a sizable stream flowing through may require additional treatment in the stream bed to completely eliminate undesirable species.

Where overabundant forage fish are protected in shallow weedy areas or other cover, a partial drawdown will force these fish to leave their cover and make them available to predators. Keeping the water level lower than normal for an extended period may allow the predators to reduce the numbers of panfish and forage fish to an acceptable level. An alternative is to eliminate some of the protective vegetation.

MECHANICAL CONTROL

Mechanical methods are most effective in reducing the numbers of fish in overcrowded situations. The use of seines, other nets, or fish traps can reduce fish numbers to acceptable levels. Such mechanical devices have the added advantage of selectivity. Desirable sizes and species of fish may be returned to the water while undesirable species or size classes are removed.

Mechanical devices are seldom effective in completely eliminating an undesirable species from a water area. Some individuals of the undesirable species will invariably escape mechanical devices, and will grow and reproduce to ensure their continued presence in the water area. Where it is desirable or necessary to completely eradicate an unwanted species, chemical toxicants will be far more effective than mechanical controls.

Interference with spawning activities is biological control, but mechanical devices are used to reduce spawning success. Sunfish species, for example, spawn several times during a summer season in Pennsylvania and have the potential to greatly outnumber other more desirable species. Disturbing spawning redds with a garden rake or other device will destroy many eggs before they can hatch. This control measure alone will probably not keep sunfish populations under control, but it will certainly reduce the reproduction rate. Dragging the lead line of a seine across the bottom of the shallow areas of a pond or lake will also destroy many sunfish eggs and redds. The same effect can be achieved by dragging a heavy chain across the pond or lake bottom in sunfish spawning areas. Such measures should be postponed until bass or other desirable species have had a chance to spawn successfully.

REGULATING LIMITS

Populations of stunted panfish frequently develop for two reasons. Many lakes receive a great deal of fishing pressure from anglers selectively removing the predators from the lakes. This eliminates one of the natural controls on panfish and forage fish. Secondly, state regulations permit the taking of some predators before they grow large enough to eat panfish of a size typical in stunted panfish populations.

Pond owners may impose size and creel limits which are more restrictive than those of the state. By regulating the size and creel limits on bass or other predators, they may be able to retain more and larger predators in a lake or pond. These larger predators will be more effective in controlling the forage species. (Except for seasons on regulated fee-fishing lakes, regulations may not be more liberal than those established by the Pennsylvania Fish Commission.)

CHEMICAL CONTROL

In an undrainable pond or lake, it is often necessary to chemically kill all the fish to correct a problem, and then to restock with the desired species or combinations of species. Chemicals are often used to eliminate fish from isolated pockets or from backwater areas in large bodies of water where a drawdown is the principal method of fish control.

When chemicals are used, the water level of the pond or lake to be reclaimed should be lowered as much as possible. This will prevent the immediate outflow of toxicant into downstream water areas. As the pond or lake refills, the fish toxicant will become more and more dilute, and--if the pond fills slowly enough--most or all of the fish toxicant will have decomposed and be harmless before it spills out into downstream waters.

Under the law, the owner of the water area being treated is responsible and liable for any fish kills which occur downstream as a result of the treatment.

After the pond or lake level has been lowered as much as possible, the volume or weight of the water to be treated must be calculated. Procedures for determining water volume or water weight are discussed in the section dealing with chemical control of aquatic plants.

A few fish toxicants are selective--they will kill only certain species. The specificity is achieved by using different concentrations of the chemical. An overdose through error or carelessness can result in a total fish kill.

When a liquid fish toxicant is used, the chemical must be diluted sufficiently for complete and even coverage of the area to be treated. Powdered toxicants are mixed with water to form a thick paste which is placed in a tightly woven cloth sack and towed behind a boat until even coverage is achieved.

A partial fish kill may be achieved by treating only a part of a pond or lake. Panfish usually inhabit the shallower areas of a pond or lake, while the gamefish inhabit the deeper waters, especially during midday. If a shallow area is known to harbor a large number of panfish, it may be possible to partially eliminate a stunted population by treating only such shallow areas.

Decide the extent of the area you wish to treat. Begin treating the area at the farthest point from shore and seal off the area to be treated; then work toward shore with a curtain of fish toxicant. If the area is a shallow cove, seal off the mouth of the cove with a curtain of fish toxicant and then proceed into the cove, treating the water as you go. When done in this manner, fewer fish will escape the toxicant. If treatment is begun at shore, the fish will move into deeper water ahead of the toxicant and escape.

Do not treat shallow areas at times when predators are likely to be feeding in those areas. Avoid such treatment on windy days when the toxicant might drift into areas where a fish kill is undesirable. Avoid shallow areas where young gamefish are likely to be present in substantial numbers.

Use only enough toxicant to kill the target species. As the toxicant mixes with the remaining pond or lake water, it will become diluted so that no kill should occur beyond the prescribed boundaries. A heavy dose or an overdose applied in a shallow area could result in a total kill over the entire pond.

Extreme caution must be exercised where the water level cannot be lowered and where an overflow from the pond into adjacent waters is possible. In such cases it may be necessary to treat the outflow to detoxify the chemical. Detoxification can also be implemented if a pond owner wishes to restock his water before the toxicants would naturally decompose. Both rotenone and antimycin (fish toxicants) can be neutralized with potassium permanganate ($KMnO_4$).

Decomposition of toxicants depends on temperature and pH. Most fish toxicants decompose more rapidly at higher temperatures and at higher pH levels. The manufacturer's label will give instructions for the amount of detoxifying chemical needed for various water temperatures and pH levels. The label will also explain how to determine whether detoxification has been achieved.

LEGAL RESTRICTIONS

Drawdowns

Farm pond owners should contact the district Waterways Patrolman when planning a drawdown. A Waterways Patrolman will supervise the disposal of any fish in the pond. Owners of large bodies of water will need a drawndown permit, available from the Pennsylvania Fish Commission. Applications are available from Waterways Patrolmen or from Fish Commission regional offices.

Net Permits

The Pennsylvania Fish Commission requires a permit to buy or possess a net larger than four feet square or four feet in diameter. Applications are available from district Waterways Patrolmen or from Fish Commission regional offices.

Chemical Permits

A permit is required from the Pennsylvania Fish Commission to apply fish toxicants to any water area in the Commonwealth. A sample application is included in the section about chemical control of aquatic plants.

Fish for Restocking

The Pennsylvania Fish Commission places restrictions on the importation and release of certain species of fish into water of the Commonwealth. Species suspected or known to be detrimental to native Pennsylvania fishes or to aquatic environments in the state are prohibited. Check with district Waterways Patrolmen for a list of prohibited species.

CONVERSION TABLE OF MEASUREMENTS

AREA AND VOLUME

1 acre = 43,560 square feet (length times width)
1 acre = a square with 208.7 feet on each side
1 acre = a circle with a diameter of 235.4 feet

1 acre foot = 325,851 gallons water
1 acre foot = 2,718,144 pounds water
1 acre foot = 43,560 cubic feet water

LIQUID MEASUREMENTS

1 gallon	=	4 quarts
1 gallon	=	8 pints
1 pint	=	16 ounces
1 cup	=	8 ounces
¼ cup	=	2 ounces
½ cup	=	4 ounces
1 tablespoon	=	½ ounce
8 tablespoons	=	4 ounces
16 tablespoons	=	8 ounces
0.1 gallon	=	13 ounces
0.2 gallon	=	26 ounces
0.25 gallon	=	32 ounces or 1 quart
0.3 gallon	=	38 ounces
0.4 gallon	=	51 ounces
0.5 gallon	=	64 ounces or 2 quarts
0.6 gallon	=	77 ounces
0.7 gallon	=	90 ounces
0.75 gallon	=	96 ounces or 3 quarts
0.8 gallon	=	102 ounces
0.9 gallon	=	115 ounces
1.0 gallon	=	128 ounces or 4 quarts

SOLID MEASUREMENTS

0.1 pound	=	1.5 ounces
0.2 pound	=	3 ounces
0.3 pound	=	5 ounces
0.4 pound	=	6 ounces
0.5 pound	=	8 ounces
0.6 pound	=	10 ounces
0.7 pound	=	11 ounces
0.8 pound	=	13 ounces
0.9 pound	=	14 ounces
1.0 pound	=	16 ounces

MISCELLANEOUS

1 part per million = 8.345 pounds per million gallons of water
1 part per million = 2.7 pounds per acre foot of water
1 gallon of water weighs 8.3453 pounds
1 pound of water equals 0.1198 gallon

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